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W. E. FOREST, M.D.,

New York.

Reprinted from THE AMERICAN JOURNAL OF OBSTETRICS AND DISEASES OF WOMEN AND CHILDREN, Vol. XIX., July, 1886.

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COLLEGE OF PHYSICIANS AND SURGEONS
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INTUSSUSCEPTION IN CHILDREN.

Case I.—In July, 1880, a child eight months old was brought to me for treatment for diarrhea. It was much reduced in flesh and strength. I saw the child one afternoon, and recommended the mother to take it to the sea-shore the next morning, and remain on the beach during the day. The same evening the mother noticed a lump in the right hypochondriac region that moved at times towards the left side.

The child passed a restless night, occasionally screaming, and the diarrheal discharges gave place to bloody passages, accompanied with tenesmus. In the morning, without seeing me or notifying me of the new symptoms, the child was taken to the sea-shore. The mother had already noticed that, after violent expulsive efforts, what she called the child's "body" came down. During the day the child had occasional attacks of screaming and straining, accompanied by the same bloody discharges. In the evening I was called in, this being about twenty-four hours after symptoms of intussusception had become prominent. Found the little patient with a rapid pulse, eyes sunken, cold, and vomiting. No tympanites.

An oblong tumor could be felt in the left iliac region. When the abdomen was manipulated, the child made expulsive efforts which forced out about two inches of the invaginated intestine.

The diagnosis was readily made. I at once attempted to remedy the difficulty. The patient was held in a reclining position, with head and shoulders lower than the hips, and attempts were made to force back the invaginated intestine by means of injections of warm water through a Davidson's syringe. The sphincter ani was so markedly relaxed that two fingers passed through without difficulty, and, owing to this relaxation, it was impossible to confine the injections in the bowel. As soon as

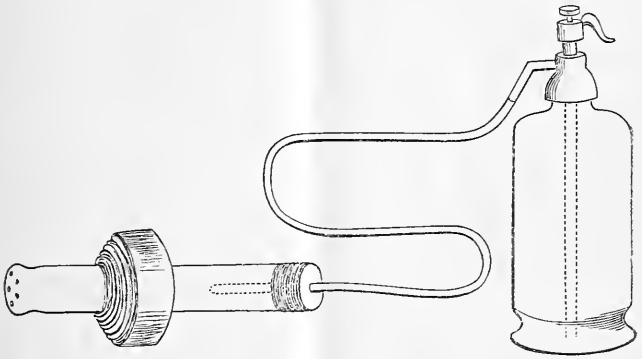
three or four ounces had been thrown in, an expulsive effort would drive out every particle of the liquid at the side of the nozzle of the syringe, and force the intestinal tumor down upon the syringe nozzle with considerable force.

Finding my efforts unavailing, I called in a neighboring physician to assist me. The child was suspended for a few minutes with its head downwards. The assisting physician held the nozzle of the syringe in the anus and supported the relaxed sphincter with his hands, while I attempted to inject warm sweet oil. In spite of the position of the child and every endeavor on the part of my assistant to constrict the anus and retain the injection, it was expelled repeatedly. The expulsive force of the abdomen in this weak child was almost incredible. After intermittent attempts for more than two hours, we were compelled to give up these efforts and to propose the operation of abdominal section. To this the parents would by no means consent, and so, it being nearly midnight, we left the case for the night. On my way home I thought of a measure that might perhaps be of service. I stepped into a drug store, and procured an old-fashioned glass vaginal syringe, one inch in diameter and six inches in length, with a rounded end, perforated by a number of small openings. From the syringe I removed the piston and fitted a cork in the open end, with a hole in the cork just large enough to receive the nozzle of a Davidson's syringe. I removed the rubber tube with the nozzle in front of the bulb of the syringe and passed the nozzle through the hole in the cork. A little melted sealing-wax dropped on the cork held the nozzle in place firmly, and made the joints air-tight. The other end of the rubber tube was then slipped over the nozzle of a siphon of Vichy water and fastened. I then made a shoulder on the glass vaginal syringe about an inch from the perforated end, by winding a roller bandage tightly around it. This bandage was wound so as to make a firm shoulder an inch in thickness all around the tube, and made slightly cone shape. My apparatus consisted, then, of a siphon of Vichy water warmed to the temperature of the body, a small rubber tube about two feet in length connecting the siphon with a glass tube one inch in diameter and six inches in length. The end of the glass tube that entered the rectum was rounded and perforated with a number of openings. One inch from this extremity was a shoulder formed by a roller bandage.

The apparatus being complete, I proceeded to put it to the test. The glass syringe was inserted in the anus until the shoulder on it pressed firmly up against the parts about the sphincter ani and thus supported them. Then I cautiously depressed the cock on the siphon. Not till this moment did the completeness, and (if I may be allowed the expression) the beauty of the apparatus appear.

Whereas with the ordinary method of injection, two physicians had found themselves totally unable to force any considerable

amount of liquid into the intestine, owing to the relaxation of the sphincter and the powerful expulsive efforts of the child, now by the pressure of one finger upon the cock of the siphon I was enabled to give an injection without the escape of a drop of the injected fluid. With the utmost ease I could bring to bear upon the invaginated intestine an elastic pressure of gas and water that might be increased at will up to almost any amount. Very slowly then, barely a drachm at a time, I allowed the gas and liquid to escape from the siphon into the glass tube and so into the colon. When an expulsive effort came on I at once stopped the injection, when part of the fluid would be driven back into the glass tube



and there meet with an elastic cushion of carbonic acid gas, that while yielding somewhat to the expulsive force of the abdomen, still kept up a continuous pressure on the tumor and gradually forced it upwards. In twenty minutes I found by abdominal palpation that the tumor had risen somewhat in the left iliac fossa, and that the *expulsive efforts of the child were less violent*. Thirty minutes later, no marked tumor could be felt in this region, but there was still an obscure swelling in the right hypochondriac region.

I then had the child held in a semi-reclining posture, with the shoulders higher than the nates, so that gas might rise upwards, and inverted the siphon so that carbonic acid gas alone could escape from the siphon into the rectum. As the gas rose up through the portion of the colon below the tumor and pressed against it, there was a faint rumbling sound and immediately all signs of an intussusception disappeared. The child was then given an anodyne, and soon fell into a quiet slumber. Two hours later, a natural feculent discharge came from the bowels.

CASE II.—An infant, five months old, in ordinary good health except that it was teething and had a slight diarrhea, was taken in the evening with sudden attacks of crying and screaming.

These attacks were paroxysmal in character. The child vomited occasionally. About 2 A.M. to these symptoms were added discharges of blood accompanied by marked tenesmus. The parents then summoned me. I found the symptoms already mentioned. The child was pale, but not yet collapsed. Suspecting what the trouble might be, I at once examined the abdomen and found a tumor in the left hypochondriac region. On passing the finger through the dilated sphincter, and as far as possible into the rectum, it came in contact with the end of the invaginated portion of the intestine.

The diagnosis was plain. Without delay I procured my simple apparatus and the siphon of Vichy, and commenced giving the injection. The tumor was gradually forced upwards. The expulsive efforts of the child became less and less violent as the tumor rose, until at length, before the invagination was reduced, the child fell into a doze. It had had neither opium nor an anesthetic. In one-half hour there was no sign of a tumor present. There was a faint rumbling sound at the close, much as is heard when a hernia is reduced. I gave the child an opiate. The next day it appeared well and made a good recovery.

CASE III.—In April, 1885, I was called to see a girl of 5 years, who had had intermittent pain in the abdomen for two days. She then began to have well-marked tenesmus with the passing of blood.

On examining the abdomen, I discovered a tumor in the right hypochondriac region. This tumor was movable slightly and during a pain became somewhat harder, "rose up" under the hand, and moved slightly upwards. The patient, however, was very comfortable between the paroxysms of pain, there was no collapse, no vomiting, and no dangerous symptoms of any kind, such as were present from the first in cases I. and II. Tenesmus was well marked, however.

In making the differential diagnosis in this case (and I must confess I was a little in doubt at first, owing to the absence of acute symptoms), I had to consider whether the tumor might not be impacted feces. Against this theory was the "feel" of the tumor itself: it did not have the doughy feel that impacted feces are said to have in most cases. The tumor, too, was somewhat erectile, which is said to be characteristic of a tumor due to intussusception. Then again, in impacted feces there is rarely marked tenesmus and passing of blood unless the impaction is in the sigmoid flexure, which was not the case here, the tumor being in the region of the ascending colon.

From these considerations I decided that it was a case of subacute intussusception, probably ileo-cecal. Owing to the absence of acute symptoms, I decided to treat the case tentatively, and immediately began to carefully administer opium, and then waited for other indications before commencing active treatment. After a few hours the pain and tenesmus gradually subsided.

Fomentations of the abdomen were then added to the other treatment. The patient passed a comfortable day and night.

The next day (twenty-four hours after beginning treatment), the tumor was present, but slightly smaller. A little blood still passed, but tenesmus was absent. I continued the treatment and employed massage to some extent.

The third day the tumor could not be felt. In the evening the child had a passage of natural consistency and made a speedy recovery. There was no evidence in the passage of hardened feces.

Intussusception or invagination of the bowel in children is an affection of great interest to the physician, not so much because of its frequency, though it occurs oftener than is usually supposed, but on account of its dangerous tendency unless promptly and carefully treated.

The varieties of invagination, classified according to situation, are four.

1st. Invagination confined to the small intestine.

2d. Ileo-colic: the small intestine passing through the ileo-cecal valve into the colon.

These two varieties are extremely rare in children under ten years of age, and it is doubted by some writers whether the first ever occurs in small children.

Bristowe says "jejunal and iliac intussusception (*i. e.*, intussusception of the small intestine) is met with generally, if not exclusively, in adults."

3d. Ileo-cecal: the cecum and ileum pass into the colon, but the ileum does not pass through the valve.

The cecum enters the colon, dragging the ileum with it, the ileo-cecal valve forming the lowest end of the tumor. The cecum and the upper part of the colon are gradually inverted as the tumor descends.

This variety of invagination forms forty-four per cent of all cases both in adults and children. It probably forms between eighty and ninety per cent of all the cases occurring in children.

4th. Colic invagination; colon passing into colon. This forms eight per cent of all cases, but probably a larger per cent than this in children.

From the foregoing it will be seen and must be borne in mind, as it has a practical bearing on the treatment, that, in

nearly every case of intussuception in children, the colon alone forms the sheath or outside layer of the tumor, and that the invaginated portion of the intestine can be acted upon by a pressure from an injection thrown into the colon.

Cause.—The cause of intussusception is given as unknown in sixty-two per cent of all cases. In eight per cent diarrhea or dysentery is given as a cause. It is probably due in every case in a child (when there is no polypus or malformation of the intestine) to disturbed nerve action in the intestine; a want of rhythm of action between the circular fibres of contiguous parts of the intestine. The experiments of Nothnagel are interesting in this connection. He exposed the intestines and mesentery in a living animal, and applied the faradic electric current to a small area of the mesentery. A portion of the intestine a few inches in length, connected with the part of the mesentery acted upon, contracted firmly into a dense cord-like condition. The intestine just below this portion, not being acted upon by the electric current, and hence retaining its natural calibre, gradually rose up around the contracted intestine and inclosed it, thus forming a perfect intussusception. Now apply this view of the cause of intussusception to the human subject. A child, from some one of the many possible causes, has the nervous action of the intestine disturbed; it has a colic in fact, a wave of spasmodic contraction and relaxation either commences near or travels down to the lower end of the ileum.

The cecum, the beginning of the large intestine, is large, and in the child very movable. As the ileum near the valve contracts spasmodically, the larger cecum slips up around it and the intussusception is commenced. Now every paroxysm of pain tends to increase this condition by pushing the ileum further and further into the colon, turning the upper part of the colon inside out, until at length, in severe cases, perhaps in a few hours, the extremity of the ileum, with the ileo-cecal valve, will protrude from one to six inches outside of the anus. The usual cause of intussusception then must be some disturbance of nerve action in the intestine. However interesting this theory of the cause of intussusception may be from a scientific standpoint, it has no practical bearing whatever. There is no method of knowing when the child is in danger of an attack of intussusception, for in many cases it comes on apparently in a mo-

ment, in children that seem perfectly healthy. Weakly children, and those subject to intestinal troubles, are probably more liable to it than others.

Diagnosis.—The diagnosis is a subject of the greatest importance. In reading histories of cases of intussusception as we find them given from time to time in the medical journals, one is struck with the fact that in a majority of the cases an erroneous diagnosis is made at first, and a wrong course of treatment pursued.

Either the case is thought to be one of obstinate constipation and is treated for a time by purgatives, such as croton oil, calomel, jalap, liquid mercury, or bird-shot, much to the detriment of the patient; or, on the other hand, it is thought to be a case of severe wind-colic or dysentery, and is treated with opium.

After a day or two of such treatment, the physician either discovers his mistake, or some one is called in who recognizes the true state of the case.

Now there is no inherent difficulty in making a diagnosis of this affection in children, in the majority of cases. Mistakes are made, because the physician is not on the lookout for this condition, and because the symptoms resemble somewhat certain minor affections.

The characteristic symptoms are four: *pain, bloody discharges, tenesmus, and a tumor.* The pain in acute cases is paroxysmal in character, is sharp and cutting, and causes the child to scream. In itself this is not characteristic, but taken with the next symptom it becomes of great importance. A discharge of blood is one of the most important symptoms. It appears a few hours after the attacks of pain, and is almost invariably present during the course of the disease. There are but three affections in children that, so far as I know, give rise to bloody discharges from the anus. These are dysentery, mucous polypi, and intussusception.

Polypi need never be confounded with intussusception, because the symptoms are not acute, and they are not accompanied with cramp-like pains, and constitutional disturbances.

The diagnosis between intussusception and acute dysentery is a little more difficult. Dr. J. Lewis Smith says that, in most of the cases of intussusception where he has been called in consultation, he has found the patient under treatment for dysentery.

The points of difference are that there is more blood and little, if any, slime in intussusception, while in dysentery there are slimy, foul-smelling discharges, tinged with blood. In intussusception the attack is generally more acute than in dysentery, the pain is greater, and more like colic; finally, there is a tumor that may usually be found by a careful examination.

Blood is always present in these cases in young children, but in children over ten years of age, and in adults, it may be absent.

The *tumor* is the characteristic sign. This is present and can be found in about eighty per cent of all cases, and in children probably in a much greater percentage of cases. In the search for the tumor, if the child is very fleshy, or the abdominal wall resisting, the patient may be safely put under the influence of ether or chloroform.

Generally the tumor will be found in the left hypochondriac region. The location, however, is not constant by any means, and it may be found in any region of the abdomen.

The tumor is oblong in shape; it is movable, changes its position during an attack of pain, and is erectile to a certain extent when the child strains.

Not infrequently the tumor appears at the anus, or may be reached by passing the finger into the rectum.

Is it possible to mistake a tumor of this character, when associated with some or all of the symptoms previously mentioned, for anything but an invagination? The pain, the blood, the constitutional reaction, the throes and strainings of the child without passing feces, and the erectile tumor are the practical signs. Not all of them may be present in every case, but some of them must be.

There are other symptoms of intussusception, but they are by no means so characteristic as those just given. Vomiting is usually present, but this is so frequently present in children's diseases that it is no guide for the diagnosis of intussusception.

In the cases I have seen, there was a marked relaxation of the sphincter ani: in children less than a year old, two fingers passed easily into the rectum.

This symptom points to some affection of the large intestine.

With many or all these symptoms present, there will be little trouble in making a diagnosis, if the physician is ready to appreciate the meaning of them.

In subacute and chronic cases, these symptoms mentioned above are not so prominent. There may not be great pain; a paroxysm not very severe is succeeded by a long interval of ease; constipation may not be present for some time; blood will appear at the anus after a time, and careful search will discover a tumor somewhere in the abdomen. But on account of the comparative rarity of the disease, and the lack of urgency in the symptoms, a careful examination of the abdomen may not be made, and hence a mistaken diagnosis is held for severa days. The only way to avoid these mistakes is, in every case of colic or bloody discharges in a child, to make a very careful manipulation of the abdomen for the possible presence of a tumor. The importance of making an early diagnosis in this affection must be evident.

Treatment.—In the treatment of this affection drugs play an altogether secondary part. Cathartics, of course, are contra-indicated.

The English authors speak of belladonna and opium as being useful, the belladonna to relax the intestinal spasm and to restore the rhythmical action of the unstriped muscular fibre; the opium to relieve pain and prevent shock. The uncertainty as to how much opium may be given with safety to a child makes me afraid to use it to any extent in this affection, though I should certainly give it. It will require a poisonous dose to relieve the pain of intussusception, and if the tumor should be reduced while the opiate is yet in the system, death might occur from opium poisoning. A small dose frequently repeated, to counteract shock and quiet intestinal action, may be safely given, but for the relief of pain and spasm during attempts at reduction, chloroform or ether will be safer and more serviceable than opium.

Spontaneous cure by sloughing of the invaginated portion of the intestines is hardly worth considering in the case of children under five years of age. Bristowe speaks somewhat doubtfully of the value of active treatment in this affection, and says that we may well give the child the chance of recovery by spontaneous cure. But he likewise says that if the invagination occurs in the large intestine, recovery by sloughing almost never takes place; and in another connection he says that intussusception in children rarely, if ever, occurs, except in the large intestines.

Putting these statements together, it becomes plain that childen, unlike adults, can rarely recover spontoneously.

Treves' statistics show that spontaneous elimination of the invaginated intestine in children under two years of age takes place in only *two per cent of the cases.* Even in the cases of spontaneous elimination the child very rarely recovers, but dies from peritonitis or exhaustion. Between two and five years of age, spontaneous elimination (not cure) takes place in only six per cent of the cases; between six and ten years of age in thirty-eight per cent. Hence, active treatment of some kind is indicated. Bearing in mind what has been said previously as to the usual location of the disease in children, it will at once be plain that pressure on the tumor by injections through the colon will be a reasonable method of treatment. This treatment is as old as Hippocrates.

There are several things to be considered before giving an injection for intussusception.

1st. When does *adhesion* between the coats of the invaginated intestine take place; for, obviously, it would not be safe to try to force back the tumor after adhesion and sloughing had commenced. The very shortest time on record when adhesions had taken place between the coats of the invaginated intestine is three days. The average length of time is five to seven days. Even then these recent adhesions are soft and yield to pressure, and are not a bar to careful attempts at reduction.

2d. When does *softening* and *sloughing* of the bowel commence in these cases? This very important question cannot be definitely answered. The time varies remarkably. In the *ultra* acute cases (which happily are very rare) sloughing may commence in twenty-four hours. In the ordinary acute cases three days would be about the minimum time. In subacute cases a week or more may pass before sloughing takes place.

3d. What form of injection is the best: liquid, or gas, or a combination of them both; and how shall the injection be best administered?

In answer to this I can say that I found the *siphon* arrangement I have described very convenient and effective in the cases in which I used it. Certain facts about these siphons should be borne in mind before employing them. They contain either saline or pure water charged with carbonic acid gas.

They are charged under a pressure of from one hundred to one hundred and twenty pounds to the square inch. Each cubic inch of water under this pressure absorbs about five cubic inches of gas, four inches of which will be liberated as soon as the water escapes from the pressure within the siphon. Hence when one cubic inch of water has escaped from the siphon into the bowel we have in reality given a volume of gas and liquid that occupies space equivalent to five cubic inches. Hence the liquid should be allowed to escape very slowly, barely a drachm or two at a time; we must bear in mind that we have a force in the bottle sufficient to rupture the intestine instantly if employed carelessly. Another caution to be observed in the use of the siphon is to avoid exposing it to any considerable heat in warming it, for fear of an explosion.

It may be said that the siphon cannot always be obtained when needed, especially in country districts. If the siphon is not at hand, one can be improvised in fifteen minutes in the following manner: Take a strong bottle or jug holding a pint of water. Fill it and then put in two ounces of bicarbonate of soda and an ounce and a half of tartaric acid. Cork instantly, tie in the cork, cover with melted sealing-wax, and then screw a champagne faucet through the cork. By slipping the rubber tube over the faucet and inverting the bottle we have a siphon that answers every purpose.

Ziemssen speaks very highly of carbonic acid gas in the treatment of intussusception. He seems to think it has some specific effect on the coats of the intestine that favors the reduction of the invagination.

He recommends a measure in the use of it that cannot be employed with safety, in children at least. He says that twenty grains of bicarbonate of soda may be dissolved and injected into the rectum. Then fifteen grains of tartaric acid in solution may be injected. The chemical union of the two will set free a large volume of carbonic acid gas within the colon.

4th. *What syringe should be used?* After a careful consideration of the subject and many experiments, I have become satisfied that we should use the *fountain syringe* only in treating these cases.

The surgeon should know exactly how much force he is exerting on the walls of the intestine every moment. If accuracy is important in any surgical operation, it is important in this

one. The danger is not greater in using too much force than in using too little. In the former case, the intestine is ruptured and death ensues; in the latter, the injection having been tried with too little force, the tumor is wrongly declared irreducible by injection, and the child is left to die unaided, or it is at once decided that an operation by laparotomy is the only resource.

To illustrate how absurdly injections are often given in these cases, let me give the outlines of a case reported in the *Maryland Med. Journal* for December, 1884:

A surgeon was called in consultation in a case of intussusception in a child two years of age. He says that in attempting to reduce the invagination by injections, the child was inverted and a funnel inserted into the rectum and water poured into this. This method failing to reduce the tumor, and the parents not consenting to the operation of laparotomy, the child was left alone. At length the parents consented to the operation; the abdomen was opened and the tumor easily reduced. The child, however, died from exhaustion and shock.

The surgeon reporting the case draws the moral that the operation of laparatomy should be resorted to early in these cases. It does not occur to him that a pressure from within the colon against the tumor by liquid or gas injected with *sufficient force* might have done in the beginning what his fingers in the abdominal cavity did two days later, namely, reduced the non-adherent tumor. A force of possibly a half pound pressure to the square inch was employed by his injection, when he might have used with safety, and should have tried at least, a pressure of five or six pounds to the square inch, before deciding that injections were useless.

Another case was reported in the *N. Y. Med. Journal* a few years ago. The physician says: "I at once suspected it to be a case of intussusception" (the tumor was present and every symptom needed to make a positive diagnosis) "and ordered an enema of tepid soap and water to be repeated every two or three hours until a fecal discharge should be obtained. On my return next morning I was informed that no passage had been produced." Injections thus administered do not tend to force back the invagination, but to increase it. The colon is stimulated to make expulsive efforts and thus drive the intestinal tumor further down.

The *Davidson's syringe*, the usual means used in giving injections for the cure of intussusception, is a wholly untrustworthy

instrument and should never be used if the fountain syringe can be obtained. The amount of force evolved by compressing the bulb of the Davidson syringe depends on the muscular power of the operator, and cannot be even approximately measured. In one case it may be enough to rupture the intestine instantly, and in another not as much as might have been used with perfect safety.

Surgeons would perhaps be surprised did they know how much force can be obtained from the Davidson's syringe. I find that the grasping power of my own hand as measured by the dynamometer is about *ninety* pounds. Now, apply this force to the bulb of a Davidson's syringe, and if the syringe be a good one, we can bring to bear on a column of water within the colon a pressure of ninety pounds to the square inch, provided, of course, the colon does not rupture. Experiments, given later, show that it will usually rupture under a pressure of fifteen pounds to the square inch. Hence with the Davidson's syringe the surgeon does not know whether he is exerting a pressure of five or thirty pounds to the square inch in the colon. This syringe, then, is not an instrument of precision at least. Then again the intermitting force given from the Davidson's syringe is objectionable. It tends to excite peristaltic action in the intestines which should be avoided as much as possible.

Injection of air: insufflation by means of a bellows is frequently practised in England in the treatment of these cases This method is open to the same objections and on the same grounds as the treatment by the Davidson's syringe.

Bryant, of London, reports a number of cases where the intestines were ruptured by insufflation from a bellows. This method, then, is not unaccompanied with danger.

A still more dangerous instrument is the one that succeeded in cases I. and II. reported by me, namely, the *siphon* of *Vichy* or *carbonic acid* water. I am surprised to find that Treves, in recommending this method of treatment, gives not one word of caution as to the dangers to be guarded against. The precautions to be used are given on a preceding page and need not be repeated here.

The most dangerous method of all in the treatment of these cases is that recommended by Ziemssen, namely, to first inject a solution of bicarbonate of soda, and then immediately to inject a solution of tartaric acid so as to set free carbonic acid gas by

their union. This may not be as dangerous as exploding dynamite within the intestine, but the same principle is employed in producing force in either case, namely, a rapid chemical change with a sudden liberation of gas.

The *fountain syringe*, then, is the only one that can be used in these cases with accuracy, and therefore it is the only one that should be employed. By it the amount of force used can be accurately measured, *as every two and one-half feet in height of the reservoir above the point of delivery represents about one pound pressure on every square inch of the intestine below the point of obstruction.* Thus if the reservoir is suspended seven and one-half feet above the child, a force of three pounds to the square inch is exerted on the obstruction. If the rubber tube be fifteen feet in length and vertical, the pressure will be six pounds to the square inch. With a tube of sufficient length any pressure can be brought to bear on the tumor as desired. This law of the relation of pressure to height comes from the well-known physical fact that our atmosphere, weighing fourteen and three-fourths pounds to the square inch, balances a column of water thirty-four feet high. Hence each pound of the atmosphere balances a column of water 2.37 feet in height. It will be accurate enough for all practical purposes to say then that a column of water two and one-half feet high exerts at its base in every direction a pressure of one pound to the square inch. Hence the exact force used in giving an injection can be obtained in this manner. The only important feature about the siphon syringe is the long tube, or a number of pieces of rubber tubing that can be spliced.

Not less than from twelve to twenty feet of tubing should be at hand. The reason for this will appear later. Into the upper end of the tubing a funnel can be inserted in which to pour the water; or the water can be conducted into the tube from an ordinary pitcher on the principle of the siphon.

A convenient way of getting sufficient elevation (for most rooms are not twelve to twenty feet high) would be to have one person carry the reservoir of water to the stairway while the patient could be in the hall-way or in a room opening into the hall near the stairs. I have dwelt at some length on these details because it can only be by paying attention to them that we can treat intussusception successfully by means of injections.

Whether one use the Davidson's syringe in giving the injection or the siphon, the *recal tube* I have described as made from a glass vaginal syringe with a shoulder one inch from the end will be found a very important adjunct. By this simple contrivance an injection may be given without fear of wounding the intestine, without making painful pressure on the parts about the anus, without the escape of a drop of the liquid used, and with the utmost ease and convenience to the operator. Its effectiveness is due to the fact that during the terrible expulsive efforts of the patient the stretched sphincter is supported by the large tube and the shoulder, and thus none of the liquid used can escape. Owing to this fact we can measure accurately how large a quantity of liquid is injected. A shoulder on the nozzle of the Davidson's syringe will not answer the same purpose at all, because the diameter of the nozzle is only about a quarter of an inch and hence does not support the relaxed sphincter.

Mr. Lund, of Manchester, England, has devised a rather elaborate instrument for this purpose, consisting of a nozzle like that of a Davidson's syringe, an air-inflated rubber ring on it to press against the anus, a metallic shoulder to support the rubber ring, a double canula, and a handle to hold the whole by. This apparatus, which Treves figures and speaks very highly of, is not so simple, so cheap, so safe, or so effective as the one devised by me. So far as I know, this instrument, if I may so designate a very homely and simple contrivance, has not been before used in these cases. A trial of it alone can show its value.

5th. *How much force may be safely used in giving the injection, provided we do not think sloughing has commenced?*

I shall have to disagree with Dr. H. B. Sands in his views on this point. He says in the *N. Y. Medical Journal* for 1877: "If injection or insufflation causes severe pain, it should be considered as dangerous." This rule, of course, could not be applied if the child was under the influence of opium or an anesthetic, and one or the other should be used in most cases. Then, again, the greatest pain experienced by the child and the most violent struggles take place at the *beginning* of treatment, especially if the tumor be in the lower part of the colon.

When the injection is properly given, especially if the nozzle

I have described be used, it will be found in most cases that the pain becomes less as the force of the injection is increased, up to of course a safe limit. It was so in the cases I have reported in this paper and it is so given in reports of other cases.

My answer to the question would be that a pressure of *six pounds to the square inch* may be employed in any case seen within three or four days of the inception of the attack, provided, of course, that a lesser pressure does not succeed. This pressure could be reached very gradually by elevating the reservoir up to a height, if necessary, of fifteen feet above the patient. My reasons for deciding upon this particular amount of force as the limit to which we may go, if a lesser force does not suffice, will appear from the following experiments.

Experiment I.—Child ten days old, died of marasmus not accompanied with any fever. Opened the abdomen without disturbing the intestine. Injected cold water from a fountain syringe, the reservoir suspended five and one-half feet above the point of delivery, this giving a pressure of a little over two pounds to the square inch within the intestine. The liquid distended the colon and penetrated to the ileo-cecal valve, but did not pass that point. Manipulating the intestine so as to make slight traction on the ileum at its point of junction with the cecum, opened the valve so that the liquid passed easily while the pressure remained as before.

Suspending the child by the feet, with the head downwards, also made the ileo-cecal valves pervious, without increasing the pressure.

These experiments would seem to show that massage and position may, in some cases, aid in opening the ileo-cecal valve to the passage of an injection.

Experiment II.--Reservoir suspended nine feet above the point of delivery, thus making the pressure within the colon about four pounds to the square inch. This caused the liquid to pass the valve when aided by the position of the child, with its head downwards.

The liquid, however, did not penetrate beyond the middle of the small intestine, owing to the friction in the small intestine and the obstruction from numerous sharp turns. Experiment repeated several times, with the same result each time. The practical deductions from this experiment would be, that the pressure from the rectal injection will always be greater in the

colon than in the small intestine, and the pressure in the small intestine will decrease directly as the distance from the ileo-cecal valve.

An obstruction in the small intestine, especially if it be in the upper half, can only be overcome by the expenditure of great force at the rectum.

Experiment III.—Used the siphon apparatus described in the first part of this paper. The liquid and gas were allowed to escape very slowly. The colon, intestines, and stomach were each dilated in turn, and in a few minutes the gas bubbled out of the subject's mouth and nose. It seemed almost impossible to rupture the intestine by pressure, as long as the nose or mouth were pervious.

Experiment IV.—A ligature was placed about the small intestine five feet from the ileo-cecal valve; when the pressure became too strong to be resisted, the intestine gave way, not at the point of obstruction in the small intestine, but in the middle of the transverse portion of the colon.

Experiment V.—Child three weeks old, dead three days. Pressure from a fountain syringe, equal to five pounds to the square inch, was put upon the colon without rupturing it or even destroying its elasticity. This pressure, however, did not force the water through the ileo-cecal valve (as did a less pressure in the other case), although position of the child and manipulation of the intestines were used as aids to the injection.

Experiment VI.—By the courtesy of Dr. Taft, chemist for John Matthews, I had been furnished with a five-gallon fountain filled with water and charged with carbonic oxide gas, under a pressure of fifty pounds to the square inch. The delivery pipe from the fountain had a pressure gauge so arranged on it that the gauge measured the pressure in the delivery tube at any given moment. Now, when this tube was connected with the rectum by means of the nozzle of the syringe, and the stop-cock slowly opened, the gauge measured the pressure upon each square inch of the colon at any instant. When all was ready, the water and gas were allowed to escape slowly from the fountain and thus to gradually increase the pressure in the colon. The gas causes a more rapid and forcible dilatation of the intestines than does a liquid, even under the same pressure. A force of six pounds to the square inch was used without forc-

ing the ileo-cecal valve, and without rupturing or even over-distending the colon.

Experiment VII.—The bands of the peritoneum binding the ileum to the colon at the ileo-cecal valve were divided without cutting any of the muscular coats of the intestine. This allowed the end of the ileum to be drawn out from the colon and destroyed the integrity of the valve.

Experiment VIII.—Made an impassable obstruction in the small intestine by means of a ligature, and then turned the stop-cock so as to allow the pressure to slowly increase in the intestine up to the point of rupture. Rupture took place at about the middle of the transverse colon on the anterior surface. The intestine bore a pressure of nine and three-quarter pounds to the square inch before rupturing. The subject was a child a few months old.

It may be said here that rupture in all the experiments took place in the colon, and usually in the transverse colon. This shows, not that the colon has less resistance than the small intestine, but that in a rectal injection the pressure must always be greater in the colon than in the small intestine, even though the valve be pervious.

Experiment IX.—Male about forty years of age; died of cirrhosis of liver. Connected the colon with the carbonic acid fountain and allowed the colon to fill slowly. When the gauge indicated a pressure of nine pounds to the square inch, the gas passed the ileo-cecal valve.

At a pressure of thirteen and one-half pounds to the square inch the longitudinal bands on the colon that give it its characteristic appearance gave way in places with a snap. The pressure was allowed to run up to fifteen pounds to the square inch, and still the intestine did not rupture. The gas and water passed freely through the whole length of the intestinal canal and out of the mouth.

Experiment X.—Eight months' fetus that died during delivery. A pressure of two pounds to the square inch forced liquid through the ileo-cecal valve, and a short distance into the small intestine. A pressure of three and one-half pounds forced the liquid through the whole length of the alimentary canal and out of the mouth. A ligature was placed around the intestine at about the junction of the jejunum and ileum, and the intestines subjected to a pressure of six pounds to the square

inch. There was no rupture. It would seem from these few experiments that the following conclusions might be drawn:

a. That position and manipulation, in some cases at least, aid in forcing an injection through the ileo-cecal valve.

b. That in most cases, not in all, the valve will give way so as to permit of the passage of an injection before a rupture of the colon would take place.

c. That the valve is not the only obstacle to the passage of liquids or gas from the anus to the mouth, but that friction in the small intestine is an important factor.

d. That if an injection be given with force sufficient to cause rupture of the gut, the rupture will occur in the colon.

e. Injections cannot be relied upon to overcome obstructions in the small intestine.

f. That the colon, both in the child and in the adult, bears a surprising amount of pressure without rupture, a *force of eight or nine pounds in the infant, to twelve or fifteen pounds in the adult.*

These latter conclusions are the ones that concern us most in this inquiry. We would then be justified, in any case of intussusception in a child, where the disease has not lasted long enough for sloughing to commence, or adhesions to form, to gradually apply a pressure within the colon of at least six pounds to the square inch. This could be done by raising the reservoir about fifteen feet above the subject operated on.

If the invagination be reducible, this pressure would seem to be sufficient in any ordinary case to reduce it, for it must be borne in mind that practically the intussusception in children is always in the large intestine, and so will receive the full force of the injection. A pressure of six pounds to the square inch is a safe force to use in any acute cases seen within the first three days. If the case be subacute or chronic, this pressure would be safe to employ for any time within a week, or perhaps three weeks. Cases are reported where an injection has succeeded in reducing the invagination as late as a week after the affection appeared.

6th. How shall the injection be given? *Keep up a very slow but steadily increasing pressure until the tumor gives way or the safe limit of pressure be reached without reducing the invagination.* Then keep the pressure at this point, fifteen, twenty, sixty minutes, if necessary, meantime manipulating

the abdomen gently. Of course, if the case be thus obstinate, the child should be under the influence of ether.

I am aware that this continuous pressure is not the method usually practised or taught.

We are told to inject as much liquid as we can, and then let it run out. Then repeat the maneuvre. This method is admirable for exciting the large intestine to expel any offending substance from it, whether that be hardened feces or the invaginated intestine. Our object, however, is not to cause the expulsion of anything, but to mechanically force back an intestinal tumor.

Therefore, it seems evident that a continuous pressure will accomplish this result better than an intermittent one. It will be observed in case I. in the paper that the intermittent pressure from the Davidson syringe did absolutely no good; on the other hand, the continuous pressure from the siphon, without the escape of any of the injected liquid, soon stopped the pain and struggles of the child, and steadily forced back the tumor. It overcame the spasmodic expulsive efforts as the continuous but gentle pressure of the sound overcomes spasm of the urethra in the male.

I regard this principle of *continuous pressure* as a very important one in these cases, and one that both experience and the laws of hydrostatics would seem to indicate. In order to realize the full value of this principle, it must be borne in mind that hydraulic pressure is always the same in every direction. Hence when a column of water is put into the colon in these cases under a certain pressure, it not only is pushing back the tumor, but at the same time, and with exactly the same force, it is dilating the sheath of the tumor and compressing the tumor on every side, and thus lesssening its calibre; even for this reason alone, if for no other, the pressure should be continuous instead of intermittent, until the object in giving the injection is obtained.

There can be nothing gained in such a case by forcing back the tumor for a short distance and then allowing it to be pushed down again by an expulsive effort.

If continuous pressure be used, the injected liquid might be warm milk, or milk and water, or beef-tea, as in the fifteen to sixty minutes that this would be contained in the colon, a not inconsiderable amount would be absorbed, and thus aid to keep up the vital powers of the child.

But suppose that this plan of treatment has been faithfully tried and still the case does not yield to the treatment; what is to be done?

There are three courses open: *First.* An operation by laparotomy, opening the abdomen and attempting to reduce the invagination by traction on the intestine.

Second. Leaving the case to nature, with the chance of a cure by spontaneous elimination of the invaginated portion of the intestine; or,

Third. The use of a more forcible injection, even though there be the possibility of rupturing the intestine by so doing.

Let us consider these plans separately and in order.

Laparotomy. In recent years surgeons have advocated this method of treating intussusception as being comparatively safe, and more certain than other means of treatment.

Modern surgeons, unlike our surgical forefathers, do not regard the abdominal cavity as the ancient Hebrew did the "Holy of Holies," a place never to be entered except under certain rare conditions. On the contrary, they talk of making explorative openings into the belly, for the purpose of diagnosis, as calmly as if there was no danger in such a procedure.

It is hardly to be wondered at, then, that opening the abdomen to reduce an invagination should be looked upon with favor.

Of course, most surgeons advise a trial of other methods before proceeding to this last resort, but we find in practice that they don't "waste much time," as they call it, on insufflations and injections. For instance, Mr. Goodlie reported three cases of laparotomy for intussusception in children before the London Clinical Society. In the first case he says: "It was not thought wise to spend much time in attempts at inflation, and accordingly abdominal section was performed at once." The tumor was ileo-cecal and easily reduced, and there was no apparent reason why an injection, properly administered, might not have done just what his fingers did, *i. e.*, reduced the invagination. In case II., reported by him, the trouble had lasted but a few hours, the tumor was not large, and there was no contra-indication to attempts at reduction by injection. Yet he proceeded at once to open the abdomen. The tumor was very easily and quickly reduced. The child died, however, and Mr. Goodlie, in commenting on it, says that in a case no worse than

this he should another time try inflation before opening the abdomen.

In case III., the invagination had lasted some days, and laparotomy in this case may have been justifiable.

"Actions speak louder than words" in such cases, and show the drift of surgical opinion to be towards a quick resort to aparotomy.

Treves, of London, says: "There is no reason why in the future, with a fuller knowledge of the technical details essential to the operation, with a surer acquaintance with the clinical aspects of obstruction, and with the exercise of a sounder judgment in the selection of cases, the procedure of laparotomy should not have a mortality but little higher than that of the operation of strangulated hernia."

The height of boldness in these cases, however, is reached by Bryant, of Guy's Hospital, London. He advises in his lectures that in every case of *acute* intussusception we should not wait for other treatment, insufflation, injections, etc., but open the abdomen at once and reduce the invagination, precisely as in a case of a strangulated hernia.

In regard to Mr. Bryant's position, this question occurs: Suppose the abdomen opened; the invagination is still to be reduced. Now, can traction by the surgeon's fingers on the invaginated intestine reduce the tumor, if it be reducible, with less danger and more readily than a forcible injection into the colon?

The injection is an elastic pressure, and, as has been said, dilates the sheath of the tumor at the same time that it with equal force presses the tumor back. Can the surgeon's fingers act in this manner? Does not their tractile force act on the intestines in one or two lines, and thus would it not be more liable to tear the intestine than an equal force from a liquid injected into the colon?

Professor J. B. S. Jackson, of Harvard College Medical School, said on this point that "He considers opening the abdominal cavity for intussusception with a view to withdrawing the invagination a foolhardy procedure, since it (the intestine) would usually tear before it could be withdrawn, even in comparatively recent cases."

If, however, the danger of lacerating the intestine be the same by either method, and their effectiveness in reducing the

tumor be equal, yet how infinitely more dangerous is the treatment advocated by Mr. Bryant than that of a properly administered injection.

His method *adds* to the possibility of lacerating the intestine the certain danger of death from peritonitis or shock arising from the abdominal incisions and manipulations. The latter danger is not a slight one by any means. The abdominal cavity, in children at least, cannot be opened with impunity. Treves' tables show that after laparotomy the death-rate in children, even though the invagination was "easily reduced," is 43 per cent.

What is this high death-rate due to? Not to the reduction of the invagination, for that was "easily reduced."

It must be mainly due to the abdominal section. It will be said that delay in operating and consequent exhaustion of the patient is the cause of the fatal result. It may be said in reply that, had a properly given injection reduced the tumor *without opening the abdomen*, the patient, however weak and collapsed, would in the very large majority of these cases have quickly rallied and recovered. Numerous cases are reported where the prostration and collapse was profound and had continued for days, and yet when the invagination was reduced without opening the abdomen the patient quickly recovered. In fact, I can find no case on record where the patient died after the tumor was once reduced by insufflation or injection.

But we need to ask here, if the reduction of the invagination was "easy," why was the operation of laparotomy necessary at all?

It would seem, from the nature of the problem, that any case of invagination in the large intestine that can be easily reduced by the surgeon's fingers might have been safely reduced by the direct pressure of liquid injected into the colon.

The force thus exerted ought to be as safe and effective in untwisting and pushing back the intestinal tumor as the pulling and pushing by the surgeon's fingers after the abdomen is opened.

Surely, then, the grave operation of *laparotomy* should be reserved for cases that cannot be reduced by the simple operation of giving a forcible injection.

Now, what have been the results of laparotomy for intussusception in *children* where the invagination "was reduced with

difficulty or was irreducible"? According to the statistics of Leichtenstern, of Treves, and of Schramm, who have collected by far the largest number of these cases of any authors, the death-rate after laparotomy "where the invagination was difficult or irreducible" was just 100 per cent; not a single case recovered. Laparotomy has succeeded in 57 per cent of the cases where it was not indicated at all, where simpler, and less dangerous methods would have succeeded far better; and, according to statistics, has failed in every case where laparotomy was really indicated. These conclusions only apply to children under 12 or 15 years of age.

Spontaneous Cure. The *second* course open in an obstinate case is to leave it to nature. What are the statistics of operations by sloughing of the invaginated portion of the intestine, and how do these compare with laparotomy?

In the infant, spontaneous elimination takes place in only 2 per cent of the cases, and even these do not recover. In the second to the fifth year of age, spontaneous elimination takes place in only 6 per cent of the cases, and most of these die. Hence, up to the sixth year of age nature fails to cure these cases because the child's strength gives out before the slough can be thrown off.

Between the sixth and eleventh year, however, spontaneous elimination takes place in 38 per cent of the cases; and recovery takes place in 42 per cent of those that undergo spontaneous elimination. In other words, 22 per cent of all cases of intussusception that occur between 6 and 10 years of age recover by nature's operation.

We may suppose those cases of spontaneous elimination cases "difficult or impossible to reduce"—at least they never were reduced, although in most of them attempts were made to do so. When we compare nature's results in these cases with those of laparotomy in "difficult" cases, we are struck by the advantage of nature's method over that of the surgeon.

In children over 10 years of age, nature's operation gives still better results.

Hence it does not follow that, if one cannot reduce an invagination in all cases by an injection, he should, of course, call in a surgeon to open the abdomen.

This depends, among other things, on the age of the patient.

Forcible Injections. The *third* course open in any case that

resists an injection given with a safe degree of force (six or seven pounds pressure to the square inch) is to resort to still greater force, say nine or ten pounds pressure to the square inch. This cannot be done without danger of rupturing the intestine, and thus causing the death of the patient.

But it must be borne in mind that these cases are dangerous ones, at the best, and—whether we leave them to nature, or resort to laparotomy—the death rate must be very high in any case.

In children under 6 years of age, either laparotomy or nature's operation is almost always fatal; hence we would be justified in running some risk in giving a forcible injection in these cases.

Not to draw this out too far, let me state in a few words the course I would recommend in *all cases of intussusception in children.*

A pressure of six pounds to the square inch having failed to reduce the tumor after a lengthened trial, I should cautiously raise the pressure to seven and eight pounds, and even nine pounds to the square inch, depending on the acuteness of the attack and the length of time the invagination had continued. *This* having failed, what course should then be followed?

If the child be under 2 years of age, open the abdomen at once and resect the intestine. The child will probably die; but, if left to nature, the case it absolutely hopeless.

If the child be between 2 and 5 years of age, and injections have failed, the chances of cure by sloughing or from laparotomy are about equal, and the surgeon will be justified in following either course. Remember that the invagination probably cannot be reduced even by traction, and the principal object in opening the abdomen is to resect the intestine, or to perform enterotomy.

If, however, the child be *over five* years of age, and the tumor has resisted a pressure of eight or nine or ten pounds to the square inch without being reduced, we must conclude that it is irreducible.

Now, according to statistics given above, the operation of laparotomy in these cases shows a greater death rate than the cure by sloughing, the "spontaneous cure;" therefore, nature's operation, nearly hopeless as it is, should be preferred to laparotomy.

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Intussusception in children.